An Overview of Volcanologic] Applications of Infrared Remote Sensing

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Infrared remote sensing has long been applied to the study of volcanic and geothermal phenomena. The initial investigations utilized single-channel thermal imaging systems, whereas more recent work has demonstrated the utility of multispectral infrared imaging. The temperature and emissivity information recover-cd from infrared radiance measurements provide valuable insights into volcanic and geothermal processes.

The emissivity of a lava flow is influenced by the composition and texture of its surface. Recent work has shown that the progressive development of silica-rich coatings on basaltic lava flows provides a means for mapping the relative ages of the flows from multispectral thermal infrared imagery. Such imaging has also revealed that the leaching of cations from the surface of flows exposed to acidic aerosols can lead to a relative enrichment of the silica content of the surfaces. The detection of this alteration near the sites of former fumaroles or vents has been used to map the traces of abandoned lava tubes. Emissivity variations resulting from variations in texture have been used to differentiate silicic lava flows of similar bulk composition.

Multispectral infrared remote sensing has been used to map low- and high-temperature geothermal features. Due to design limitations, most thermal infrared (8 - 12 pm) instruments are best suited for observations of low temperature (< 200 “C) features such as active or recently-abandoned lava tubes, ocean entry sites, hot springs, and recently - emplaced lava flows. The observation of high temperature (> 500 °C) features, such as active lava flows, lava ponds, or fumaroles, requires the usc of visible to short wave infrared (0.4 - 2.2 pm) instruments. Most algorithms for estimating the temperature of active volcanic features assume that a pixel is composed of a high-temperature component and a component at ambient, or background, temperature. The two-component model is used to estimate the temperature of one component (the temperature of the other component must be known to the analyst), and the fraction of the pixel occupied by this component, given the radiance measurements from two or more spectral channels.

Recent work has demonstrated that volcanic SO_2 and ash plumes can be mapped from multispectral thermal infrared images. These mapping techniques arc based upon the detection of apparent decreases in ground temperature that result from the partial absorption of ground radiance passing through such plumes. Radiative transfer models are used [o estimate the amounts of SO_2 or ash that are necessary to produce the observed ground temperatures. Remote sensing is particularly well-suited for the study of dynamic volcanic processes, such as the transport and dispersal of plumes or the advance of active lava flows, due to the synoptic view, rapid mode of data acquisition, and repetitive coverage afforded by this technology.

Invited Session: “Surface Temperatures: Observations and Applications”
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